ECONOMIC ANALYSIS OF WOOD- OR BARK-FIRED SYSTEMS.

Thomas H. / Ellis

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PREFACE

The Tennessee Valley Authority, in cooperation with the U.S. Department of Agriculture and the Forest Products Research Society, is preparing three slide-tape presentations to help people evaluate wood- and bark-fueled boiler systems as alternatives to ones using oil, gas, or coal. The first two presentations cover equipment selection and estimation of fuel values; the third describes procedures for evaluating financial aspects. This report is the basis for the third slide-tape presentation. It can be used as a complement to the audiovisual program, or by itself as a guide to analysis of boiler system investments.

The Forest Products Laboratory appreciates the review and suggestions on this report from Monte R. Harold, Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife; Eldon M. Estep, U.S. Forest Service, Division of Cooperative Forestry; and Arthur B. Brauner, Executive Vice President of the Forest Products Research Society.

CONTENTS

Explanation......Under the major sections, the numbered items are the
               titles of specific slides in the slide series.

Preliminary copies of this material, originally
issued in April 1977 as an unnumbered publication,
contained an error in handling of investment credits.
This new report shows that the credit is deducted from
taxes, not from income.

T. H. Ellis

ECONOMIC ANALYSIS
OF WOOD- OR BARK-FIRED SYSTEMS

By

THOMAS H. ELLIS, Economist

Forest Products Laboratory,[1] Forest Service
U.S. Department of Agriculture

I. COMPARING ALTERNATE SYSTEMS

1. Main Things the Manager Must Know

Although a detailed economic analysis could be very complex, the basic principle is simple: compare expected costs, year-by-year, for the expected life of the system--for a residue-fueled operation and for the alternative fossil fuel system. To do this, the manager must have year-by-year estimates of:

    Equipment purchase and installation costs
    Annual operating and maintenance costs
    Annual fuel costs
    Annual wood and bark residue disposal costs
    Property taxes and insurance
    Income tax rates

The manager also must know the expected useful lives of the systems being compared.

2. A Simple Example--Comparing Alternative Systems

Here are some purely hypothetical figures to demonstrate the general procedure. In this case, it is assumed that a mill manager is planning a new installation and must buy either a fossil-fueled or a residue-fueled system, both assumed to last 10 years. Expected costs are shown below:

	System using fossil fuel	Residue-fueled system	Difference in cost
Initial investment (purchase and installation)	$ 50,000	$200,000	+$150,000
Annual fuel costs	200,000	70,000	- 130,000
Annual operating and maintenance costs	5,000	20,000	+ 15,000
Annual residue disposal costs	5,000	0	- 5,000
Expected useful life	10 yrs	10 yrs	

He estimates the cost of purchasing and installing the most suitable system using fossil fuels would be $50,000. For a residue-fueled system, the comparable estimate is $200,000.

Annual fuel costs, based on current prices, are assumed to be $200,000 for fossil fuels or $70,000 for wood or bark residue. The cost for the wood or bark residue would include their value if used as furnish for pulp or other products produced by the firm, or their net sales value if the firm has a market for residue. And it would include the cost of any fossil fuels which might be necessary to supplement wood and bark residues.

Costs of disposing of unsalable mill residues that cannot be used in the fossil-fueled system are assumed to be $5,000 per year. For the residue-fueled operation, no waste-disposal cost is assumed because unsalable residues are burned.

For simplicity's sake, in this example it is assumed that annual operating and maintenance costs include property taxes and insurance.

With this information, the manager can calculate the before tax profitability of the increase in investment cost for the wood- or bark-residue-fueled system.

3. **Profitability of the Increased Investment**
    in the Residue-Fueled System

Increase in investment	$150,000
Annual savings for each of next 10 years	$120,000
R.O.I., before taxes	79 percent

R.O.I., after taxes   about 40 percent

Present worth of annual savings at
20 percent discount rate, before taxes $503,097

The residue-fueled system is expected to cost $150,000 more than
the most suitable fossil-fueled alternative in this case. Estimated
annual savings in fuel costs would be $130,000. Yearly operating
and maintenance costs are assumed to be $15,000 higher for the
residue-fueled system, partially offset by savings of $5,000 per
year in residue disposal costs.

Thus, for an initial increase in investment of $150,000, annual
savings of $120,000 would be expected for the next 10 years. Is
the annual savings worth the initial increase in investment? In
this case, the obvious answer is yes. Ignoring taxes, the rate of
return on investment would be 79 percent. If the firm paid an
average of 52 percent state and federal corporate income tax, the
after-tax rate of return still would be about 40 percent. Again
ignoring taxes, the present value of the annual savings in cost,
using a 20 percent interest rate, would be about $503,097--an
amount considerably larger than the $150,000 added cost of the
wood- or bark-fueled system.

II. TERMS USED IN INVESTMENT ANALYSIS

Several business economics terms were mentioned above and should be
explained.

4. Interest Rate

The notion of an interest rate is familiar to anyone who ever
borrowed money from a bank or put money into a savings account.
It's simply the charge that a person or firm must pay for borrowed
money or expect to get from invested money. In practice, however,
the firm must consider many different kinds of interest rates. The
rate paid for borrowed money may vary, depending on the amount and
the length of the loan period. Similarly, the interest rate avail-
able to the firm from various sorts of investments will differ
according to the risks involved and other factors. The point is,
the mill manager must be clear about which interest rate is appro-
priate for his analysis.

5. Present Worth

    Using whatever interest rate is appropriate, the mill manager can
    calculate the discounted value today of an expected future cost or
    return or of a series of costs and returns. This value is an
    estimate of how much it would be worth spending now to avoid a
    specific unfavorable series of future expenses and incomes or to
    obtain a desirable series.

    For a single future value, present worth is the sum of money which
    would have to be invested today to produce the expected future
    amount, with a given interest rate. For example, if the interest
    rate is 20 percent per year, a payment of $100 expected 5 years
    hence is worth $40.19 today.

6. R.O.I.--Rate of Return on Investment

    Businesses commonly evaluate investment opportunities in terms of
    R.O.I.: the expected rate of return on investment. R.O.I. is
    simply the compound interest rate at which the present value of all
    costs associated with a project is expected to equal present value
    of all returns.

7. Minimum Acceptable Rate of Return

    Many firms set a floor for the lowest R.O.I. they will accept for a
    particular kind of investment. If a firm has to borrow money to
    finance the investment, it is not likely to accept a lower expected
    rate of return than the interest rate on the loan. Even if the
    firm does not have to borrow money for a project, it should estab-
    lish a lower limit on R.O.I. which would avoid spending on projects
    less profitable than others currently available.

III. DETAILED EXAMPLE

8. A More Complicated Example

    Evaluate a hypothetical $200,000 residue system as a replacement
    for one using fossil fuel, considering inflation and taxes: Having
    gone through a simple example and defined some of the terms involved
    in economic analysis, let us now consider a more complicated problem.
    In this case, it is assumed that a decision is being made about re-
    placing an existing furnace and boiler system that uses oil or gas,
    with one using wood residues.

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9. First-Year Cost Comparison

	Residue-fueled system	Present system
Initial investment at start of year	$200,000	$ 0
12 months' fuel cost	70,000	200,000
Operation and maintenance	40,000	10,000
Property tax and insurance	5,000	375

The investment of $200,000 to purchase and install the new system is assumed to be made at the start of the first year. In the first 12 months of operation, fuel costs are expected to be $70,000-- including any supplemental oil or gas plus the net sales value of any of the wood or bark residue which might otherwise have been sold or used as furnish for fiber products. Operation and mainte- nance, including electricity, mechanical, and other repairs, any labor expenses, and costs of operating any mobile equipment needed, are anticipated to be $40,000. Property tax and insurance costs are estimated to be $5,000, based on 2.5 percent of the cost of the installation. In practice, of course, property taxes and insurance rates will depend on local regulations.

Comparable figures for operation of the existing fossil-fuel system are expected to be $200,000 for fuel, $10,000 for operation and maintenance, and $375 for property tax and insurance. It is assumed that this system has a market value of $15,000, for property tax and insurance purposes.

Having made estimates of investment costs and first-year expenses, what the mill manager now must do is to project subsequent costs for the expected useful lifetime of the proposed system--comparing all costs, year by year, with expected costs for continued use of the existing fossil-fueled system.

10.   Residue System Costs for Expected Lifetime

Year	Investment	+ Fuels	Operation and maintenance	Property tax and insurance	= Total cost
0	$200,000				$200,000
1		$ 70,000	$40,000	$5,000	115,000
2		77,000	21,000	4,750	102,750
3		84,700	22,050	4,500	111,250
4		93,170	23,152	4,250	120,572
5		102,487	24,310	4,000	130,797
6		112,736	25,526	3,750	142,012
7		124,009	26,082	3,500	154,311
8		136,410	28,142	3,250	167,802
9		150,051	29,549	3,000	182,600
10		165,056	31,026	2,750	198,832

The initial investment of $200,000 is considered to be at the start
of the first year. All other costs are assumed to occur at the end
of whatever year in which they come. This is an economists' conven-
tion which doesn't have to be followed but is often used to simplify
calculations.

For this example, it is assumed that the average value of the wood
residues used as fuel will increase at a rate of 10 percent per
year, due to increasing demand for pulp and particleboard furnish
and for wood and bark fuels. Also, it is assumed that prices of
oil and gas will increase 10 percent per year. So the total fuel
cost for the proposed system, including the net sales value of the
residues plus the cost of supplemental fossil fuels, rises from
$70,000 in Year 1 to $165,056 in Year 10.

Costs of operation and maintenance are expected to be relatively
high in the first year until the system is completely adjusted.
Costs in the second year are assumed to drop, but a subsequent
increase of 5 percent per year due to rising labor costs and other
factors is expected.

Property tax and insurance costs are assumed to decrease 5 percent
per year due to depreciation. For this example, a 20-year straight-
line depreciation of installed equipment is assumed. In practice,
the firm is likely to have to continue paying property tax and
insurance fees as long as the equipment is in operation. It is
important to know exactly what local practices are for this.

11. Costs for Continued Operation of Present System

A similar list of expected costs must be prepared for the present system:

Year	Fuels	Operation and + maintenance +	Property tax and insurance	= Total cost
1	$200,000	$10,000	$375	$210,375
2	220,000	10,500	338	230,838
3	242,000	11,025	300	253,325
4	266,200	11,576	263	278,039
5	292,820	12,155	225	305,200
6	322,102	12,763	188	335,053
7	354,312	13,401	150	367,863
8	389,743	14,071	113	403,929
9	428,718	14,775	75	443,568
10	471,590	15,513	38	487,141

No investment cost for the present system is assumed in this example (although in many cases, there might be a substantial cost for overhauling an existing system sometime in the next several years). Fuel prices again are assumed to increase at 10 percent per year and operation and maintenance costs at 5 percent per year. Property tax and insurance costs are estimated on the assumption that the system has a market value of $15,000 at the start of the first year and is worthless at the end of the 10th year.

12. Cash Flow Analysis, Before Income Taxes

Now the manager is prepared to make a cash-flow analysis of the changes in cost for the proposed system as compared to the existing one. He simply subtracts costs expected for the present system from those expected for the wood-residue system.

Year	Costs for residue system -	Costs for present system =	Net change in costs
0	$200,000	$ 0	+$200,000
1	115,000	210,375	- 95,375
2	102,750	230,838	- 128,088
3	111,250	253,325	- 142,075
4	120,572	278,039	- 157,467
5	130,797	305,200	- 174,403
6	142,012	335,053	- 193,041
7	154,311	367,863	- 213,552
8	167,802	403,927	- 236,125
9	182,600	443,568	- 260,968
10	198,832	481,141	- 288,309

13. Before-Tax Profitability

        Present worth of decrease in costs
          at 20 percent interest $673,000

        Investment cost   200,000

        Net present worth   473,000

        Rate of return on investment   64 percent

Using a 20 percent interest rate to discount future cost savings, the manager calculates present worth of these savings to be $673,000 as compared to an investment cost of only $200,000. If the firm uses 20 percent as the minimum attractive rate of return, the project certainly meets that requirement.

Using either a computer program or a more tedious hand calculator and interest tables, the manager can calculate rate of return on investment, which in this case, would be about 64 percent. This means that an interest rate of 64 percent would be required to discount future savings sufficiently to equal expected investment cost, in this example.

To make the net present worth and R.O.I. estimate, the manager needs either a table of compound interest factors, or a computer program specifically designed for this purpose. The computer does very rapidly the same thing that could be done much more slowly by hand--discounting the cash flow at first one trial interest rate and then another, until a rate is found which makes the present worth of future cost savings equal the initial investment cost.

14. Compound Interest Factors

Tables of compound-interest factors are found in many engineering economics textbooks and in government publications. One example is "Tables of Compound-Discount Interest Rate Multipliers for Evaluating Forestry Investments," by Allen L. Lundgren, USDA Forest Service Research Paper NC 51, 1971. Factors for several interest rates are shown below:

Year	@10%	@15%	@20%	@25%
1	1.100	1.150	1.200	1.250
2	1.210	1.322	1.440	1.562
3	1.331	1.521	1.728	1.953
4	1.464	1.749	2.074	2.441
5	1.611	2.011	2.488	3.052
6	1.772	2.313	2.986	3.815
7	1.949	2.660	3.583	4.768
8	2.144	3.059	4.300	5.960
9	2.358	3.518	5.160	7.451
10	2.594	4.046	6.192	9.313

The manager selects the appropriate compound interest factor for each year of future cost savings and divides it into the savings estimate.

15. Calculation of Present Worth @ 20 Percent

Thus the estimated cost saving of $95,375 for the first year is divided by 1.200, the second year's saving by 1.440, and so on. Totaling the present worth estimates for each year, the manager calculates present worth for the expected life of the system to be $672,970, or approximately $673,000.

Year	Decrease in costs ÷	Compound interest factor	= Present worth
1	$ 95,375	1.200	$ 79,479
2	128,088	1.440	88,950
3	142,075	1.728	82,219
4	157,467	2.074	75,924
5	174,403	2.488	70,098
6	193,041	2.986	64,649
7	213,552	3.583	59,601
8	236,125	4.300	54,913
9	260,968	5.160	50,575
10	288,309	6.192	46,562
			$672,970

To calculate R.O.I., the manager could simply try different interest rates until he found one for which the sum of discounted future savings equaled initial investment cost.

IV. EFFECTS OF INCOME TAXES

The manager may wish to evaluate the project on an after-tax basis,
considering the effects of income taxes. He will need to consider three
major elements: investment tax credit (if any), depreciation, and taxes
on increased profits due to cost savings.

16. Income Tax Factors

   Investment credit

   Allowable depreciation schedule

   Marginal tax rate on profits

17. Tax Assumptions for This Example

   Investment credit   10 percent (e.g., 10% x
                 $200,000 = $20,000)

   Depreciation schedule   Double-declining--1st 5 years
                 Straight-line--2nd 5 years

   Effective state and
    federal income tax rate 52 percent

For the present example, it is assumed that an investment credit of
10 percent is available in the first year. The allowable credit
depends on several factors and may change from year to year, depend-
ing on tax legislation. A tax expert's advice may be needed for a
specific situation.

Depreciation for income tax purposes may be calculated on a different
basis than that used for property taxes or insurance. In the
present example, it is assumed that double-declining depreciation
is used for the first 5 years and straight-line for the rest of a
10-year lifetime is used. Again, the allowable methods of deprecia-
tion may vary from year to year, and according to types of equipment.
The effect of depreciation is to reduce the net income on which
income taxes are based. For this example, an effective state and
federal tax rate of 52 percent is assumed. Therefore, depreciation
of $40,000 in the first year is assumed to result in a $20,800 tax
reduction, i.e., 52 percent of $40,000.

18. Depreciation on $200,000 Over a 10-Year Period

The method of calculation has a large effect on the depreciation estimate for any one year. Therefore, the firm must be careful in selecting one which will best meet its particular situation.

Year	Double-declining depreciation	Straight-line depreciation
1	$40,000	--
2	32,000	--
3	25,600	--
4	20,480	--
5	16,384	--
6	--	$13,107
7	--	13,107
8	--	13,107
9	--	13,107
10	--	13,107

19. Calculation of Taxable Amount

Subtracting depreciation from expected cost savings, the manager can calculate the taxable amounts of cost savings. For example, the first-year depreciation allowance of $40,000 is subtracted from the estimated $95,375 in cost savings in calculating the taxable amount of savings for Year 1.

Year	Cost saving	Depreciation		Taxable amount
1	$ 95,375	-$40,000	=	$ 55,375
2	128,088	- 32,000	=	96,088
3	142,075	- 25,600	=	116,475
4	157,467	- 20,480	=	136,987
5	174,403	- 16,384	=	158,019
6	193,041	- 13,107	=	179,934
7	213,552	- 13,107	=	200,445
8	236,125	- 13,107	=	223,018
9	260,968	- 13,107	=	247,861
10	288,309	- 13,107	=	275,202

20. Tax Effects

Then the increase in income tax liability can be estimated by applying the expected effective rate, which is assumed to be 52 percent in this example. By this means, a schedule of net tax effects can be prepared. The investment credit of $20,000 is subtracted then from the increase in tax liability.

Year	Taxable amount	Increase in tax liability	Investment credit	Net income in tax
1	$ 55,375	$ 28,795	$-20,000	$ 8,795
2	96,088	49,966	0	49,966
3	116,475	60,567	0	60,567
4	136,987	71,233	0	71,233
5	158,019	82,170	0	82,170
6	179,934	83,565	0	83,565
7	200,445	105,594	0	105,594
8	223,018	118,423	0	118,423
9	247,861	132,213	0	132,213
10	275,202	147,129	0	147,129

21. Cash Flow Analysis, After Taxes

Having calculated the net change in taxes, the mill manager now can calculate after-tax savings. Increases in taxes are subtracted from the respective before-tax cost decreases, year by year. Thus, in the first year, a $95,375 decrease in costs is partially offset by an $8,795 increase in taxes--leading to a $86,580 saving after taxes.

Year	Investment cost	Cost savings	Increase in income tax	After-tax savings
0	$200,000			
1		$ 95,375	$ 8,795	$ 86,580
2		128,088	49,966	78,122
3		142,075	60,567	81,508
4		157,467	71,233	86,234
5		174,403	82,170	92,233
6		193,041	93,565	99,476
7		213,552	105,594	107,958
8		236,125	118,423	117,702
9		260,968	132,213	128,755
10		288,309	147,129	141,180

22. Profitability Measures, Before and After Taxes

From the schedule of cost decreases and after-tax savings, the manager now can evaluate the profitability of the proposed investment for its expected useful lifetime. Present worth of cost savings can be calculated and compared to investment cost. Using the discounting procedure described earlier, and a 20 percent interest rate, he calculates the present worth of expected cost savings to be $672,970 before taxes. For after-tax calculations, a lower interest rate probably would be used to calculate present

worth. For this example, 10 percent was used--leading to an estimate of $596,175. Either way, before tax or after tax, the present worth of expected savings would greatly exceed the $200,000 investment cost. Thus, the investment would appear highly profitable.

Present worth of before-tax savings,
@ 20 percent $672,970

Present worth of after-tax savings,
@ 10 percent $596,175

By trial and error, the manager can estimate before- and after-tax R.O.I. In this case, the estimates are 64 percent versus 43 percent-- indicating the investment is expected to be highly profitable.

R.O.I., before taxes -- 64 percent

R.O.I., after taxes -- 43 percent

V. RECAPITULATION

The procedure for evaluating a proposed investment is:

23. How to Do It

1. Estimate all cost changes for the expected
    lifetime of the equipment.

2. Calculate present worth of net yearly savings
    at the appropriate interest rate.

3. Compare present worth of savings with expected
    investment cost
                              or

4. Calculate R.O.I. and compare with minimum
    acceptable rate of return.

The primary rule is to calculate all cost changes for each year the equipment is expected to last. This includes not only reductions in oil and gas purchases, but also increases in costs due to lost revenue from wood-bark byproduct sales and increased maintenance and operating costs. Initial investment costs should include not only the equipment costs, but also installation costs and the cost of any downtime expected for the mill while the system is being

installed. Cost savings should include the value of avoiding
likely shutdowns due to natural gas curtailment. Savings also
should include any reductions in solid-waste disposal costs, if the
proposed system would use material which otherwise must go to
landfill or other disposal at a cost.

Next, using a guiding interest rate appropriate for the firm and
for the particular project, the manager must calculate present
worth of yearly cost savings. He then compares the expected present
worth of savings with initial investment cost. Or he can estimate
R.O.I. by trial and error using interest tables, or by computer,
and compare the answer with the firm's minimum attractive rate of
return--i.e., with the rate of return the firm typically expects to
get from investment opportunities of equal risk and importance.

24. Mistakes to Avoid

Forgetting to include net sales value of wood residues
as a fuel cost.

Ignoring salvage value of existing equipment.

Counting sunk costs.

Forgetting the cost of any supplemental oil or gas
fuels needed with residues.

Ignoring costs of equipment to store residue fuels.

First, some past analyses have neglected to calculate the cost of
using wood or bark which could be sold instead or used as furnish
for another operation by the firm. Any sales revenue that the firm
must forego, because it uses residues for fuels, is a cost.

Another mistake would be to ignore the salvage value of an existing
system. If some of this equipment could be resold or reused, its
salvage value should be deducted from initial investment cost of
the proposed new system. Conversely, any past investment costs not
salvageable should be ignored in the analysis; they are "sunk
costs."

Many residue-fueled systems require supplemental oil or gas during
startup. Furthermore, there may be times of the year when residue
volumes are insufficient for fuel needs. Obviously, any costs for
supplemental fuels must be included in the analysis. Also, there
may be substantial costs required for equipment and/or space for
storing residues to be used as fuel.

The examples discussed earlier were simplified to help make them under-standable. In practice, a firm might have a much more complicated set of cost changes to consider. Certainly, its tax situation will be different than that assumed for these examples. But the basic principle of the cash flow analysis described here is simple:

COUNT ALL COSTS AND SAVINGS.

VII. WORKSHEETS

Two worksheets are included in this bulletin to aid in analysis.

Worksheet A is designed for recording estimated costs of investment and use, year by year. Two or more copies of this worksheet would be needed: One for the residue-fueled option being considered, and one or more for whatever alternative systems are being considered.

Worksheet B is for calculation of tax effects and present worth, after taxes, of the added investment required for a residue-fueled system. Column 2 of Worksheet B is first calculated by comparing the yearly costs recorded in column 2 of Worksheet A. Column 12 of Worksheet B must be taken from a table of compound interest factors for whatever discount rate the manager's firm considers appropriate.

WORKSHEET A

CALCULATION OF COSTS OF ALTERNATIVE BOILER SYSTEMS

SYSTEM _____

Year (1)	Total cost this year (2)	Cost of equipment and installation (3)	Salvage value of existing system (4)	Fuels and power costs			Operation and maintenance (9)	Property tax (10)	Insurance (11)	Other (12)
				Residue (5)	Oil (6)	Gas (7)	Electricity (8)			
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WORKSHEET A

CALCULATION OF COSTS OF ALTERNATIVE BOILER SYSTEMS

SYSTEM _____

Year	Total cost this year	Cost of equipment and installation	Salvage value of existing system	Fuels and power costs				Operation and maintenance	Property tax	Insurance	Other
				Residue	Oil	Gas	Electricity				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
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WORKSHEET B

CALCULATION OF AFTER-TAX CHANGE IN COSTS

Year	Before-tax change in costs	Depre-ciation	Net change in taxable income	Change in tax liability		Investment credit		Net change in tax liability		After-tax change in costs (-) or income (+)	Compound interest factor	Present worth, after taxes
				Federal	State and local	Federal	State and local	Federal	State and local			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(col. 5-7) (9)	(col. 6-8) (10)	(col. 2-9 and 10) (11)	(12)	(col. 11 ÷ 12) (13)
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WORKSHEET B

CALCULATION OF AFTER-TAX CHANGE IN COSTS

Year	Before-tax change in costs	Depreciation	Net change in taxable income	Change in tax liability		Investment credit		Net change in tax liability		After-tax change in costs (-) or income (+)	Compound interest factor	Present worth, after taxes
				Federal	State and local	Federal	State and local	Federal	State and local			
								(col. 5-7)	(col. 6-8)	(col. 2- 9 and 10)		(col. 11 ÷ 12)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
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